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Description

Method for measuring intercell interference in a frequency channel

The invention relates to a method for measuring intercell interference in a frequency channel in a radio communication system.

In radio communication systems, messages (speech, image information or other data) are transmitted via transmission channels using electromagnetic waves (radio interface). The messages are transmitted both in the downlink from the base station to the subscriber station and in the uplink from the subscriber station to the base station.

DE 198 10 285 disclosed that the signal sources are distinguished, and hence the signals are evaluated, using methods known as frequency division multiplexing (FDMA), time division multiplexing (TDMA) or code division multiplexing (CDMA), which can also be combined with one another. One form of time division multiplexing (TDMA) is the TDD (time division duplex) transmission method, in which a common frequency band is used to transmit both in the uplink, i.e. from the base station to the subscriber station, and in the downlink from the subscriber station to the base station.

A signal mix, corresponding to a data assessment in CDMA systems, can be separated in a known manner by signal matched filtering (MF, Matched Filtering) which is respectively matched to the subscriber's spreading code (CDMA code). A receiver performing this signal matched filtering can be implemented, by way of example, in the form of a bank of correlators or in the form of a bank of RAKE receivers.

In addition, a signal mix can be separated in a known manner using "Joint Detection" (JD), which is described in DE 41 21 356 C2 and DE 43 29 320 A1, for example.

An important variable for handover procedures or channel allocation methods, for example DCA - Dynamic Channel Allocation, is the intercell interference. Within a base station's radio cell, the radio interface is used to transmit information in the uplink and in the downlink and this information is subject to interference from emissions from base stations and subscriber stations in other radio cells. This intercell interference can severely impair the transmission quality and can even result in the connection being lost.

Determination of the intercell interference using joint detection is known, by way of example, from DE 196 15 828 C2. When using joint detection, the intracell interference is eliminated by subtracting it from the signal mix received, which means that the intercell interference can be isolated from the signal mix for the purposes of improved detection. However, the use of joint detection is complex, particularly for the subscriber station.

The invention is based on the object of specifying a method for measuring intercell interference in a frequency channel in a radio communication system which does not require joint detection. This object is achieved by the method having the features of patent claim 1. Advantageous developments of the invention can be found in the subclaims.

The inventive method for measuring intercell interference in a frequency channel in a radio communication system involves transmitting information

simultaneously to a plurality of subscriber stations in the frequency channel. The information is separated using spreading codes. Such a radio communication system is known as a CDMA system, for example. Orthogonal spreading codes in a CDMA system can be separated better than nonorthogonal spreading codes. The frequency channel in a CDMA system has an appropriately broad bandwidth for spreading. Despite the use of separation methods, for example a spatial separation method SDMA (Space Division Multiple Access), transmissions from base stations and subscriber stations in other radio cells transmitting in the same frequency channel can be subject to interference. This interference is called intercell interference.

A first subscriber station measures a total received power in the frequency channel. The total received power can advantageously be determined directly from the RF received signal. For the same frequency channel, a sum of the transmitted powers for the spreading codes used by a first base station is determined. To this end, by way of example, either the RF transmitted signal from the base station is measured, or the sum of the transmitted power for the individual spreading codes used is calculated from prescribed control parameters for regulating transmitted power.

The intercell interference for the first base station's radio cell is determined from a difference between the total received power and the sum of the transmitted powers. The intercell interference can thus be ascertained particularly easily and inexpensively. Measurement of the intercell interference for a plurality of frequency channels is used to ascertain the frequency channel having the least intercell interference, for example for intracell handover.

In one advantageous development of the invention, the first subscriber station signals a measurement result for the total received power to a network device.

Signaling the measurement result makes the total received power available, in principle, to all network devices if appropriate protocols are used to ensure signaling within the network.

In one particularly advantageous development of the invention, the transmitted powers are corrected by subtracting a path loss between the first base station and the first subscriber station. In this way, the intercell interference ascertained for a plurality of subscriber stations becomes comparable, and the change in the intercell interference on the basis of the change in the path loss for a moving subscriber station is calculated and the result made more precise. The path loss is calculated from the difference between transmitted power and received power on a pilot channel. The received power is measured by the subscriber station. Appropriate signaling is used to make the received power and/or the path loss available likewise to at least one network device.

It is advantageous for the measurement of the total received power and the determination of the transmitted powers to take place simultaneously, so that the transmission conditions, which are variable over time, do not corrupt the measurement result unnecessarily. It is useful if the powers are determined within one time interval or time slot and the intercell interference is ascertained.

Advantageously, the intercell interference is measured within one time interval. The time interval is either prescribed - for example by the network operator - or is stipulated temporarily by a network device for

allocating radio resources, the base station or the subscriber station. Short time intervals limit the measurement complexity.

If, by contrast, the intercell interference is measured over a long time interval, where is the measurement made more precise and resources for signaling the measurement results are saved.

Particularly advantageously, the time interval is at least part of a time slot in a TDMA system. If the time interval is appropriately short, various frequency channels are measured within the period of one time slot, which provides a very large number of measurement results relating to a plurality of frequency channels within a very short time. This is particularly advantageous for initial access by a subscriber station, since a connection needs to be set up as quickly as possible and, in accordance with the invention, it is necessary to ascertain measurement results for transmission channels with the best possible transmission quality within a short time span.

If, by contrast, a connection has already been set up, the intercell interference is advantageously measured over a plurality of time slots. Thus, by way of example, the intercell interference is measured in the first time slot of a frame in six successive frames.

If the total received power is measured and a pilot channel is transmitted in the same time interval or time slot, then the measurement result for the intercell interference is corrupted by the pilot channel's received power. Advantageously, the measurement result for the total received power is reduced, and hence corrected, by subtraction, by the measurement result for the received power on the pilot channel. This presupposes that the subscriber station

is able to measure the pilot channel's received power separately from all other received signals.

The invention is explained in more detail below using exemplary embodiments with reference to drawings, in which

FIGURE 1 shows a block diagram of a radio communication system, in particular of a mobile radio system,

FIGURE 2 shows a schematic illustration of the radio interface between base stations and subscriber stations, and

FIGURE 3 shows a schematic illustration of the sequence of the inventive method.

The radio communication system shown in FIGURE 1, and, by way of example, in the form of a mobile radio system comprises a multiplicity of mobile switching centers MSC which are networked among one another and set up access to a landline network PSTN. In addition, these mobile switching centers MSC are connected to at least one respective device for allocating radio resources RNC. Each of these devices RNC in turn allows a connection to at least one base station BS1 or BS2.

This base station BS1 is a radio station which can use a radio interface to set up and signal communication links to mobile or fixed subscriber stations MS1, MS2 and MS3 within a radio cell FZ1. The functionality of this structure is used by the inventive method. Use in a wireless subscriber access system (Access Network), for example, is likewise possible in this context.

In the exemplary embodiment, the base station BS1 has set up a plurality of communication links to the

subscriber stations MS1, MS2 and MS3 in a frequency channel FK. To separate the information to be transmitted, each subscriber station MS1 to MS3 uses an individual spreading code sk1, sk2 and sk3.

Another base station BS2, which covers an adjacent radio cell FZ2, for example, has set up a communication link to the subscriber station MSI. For the communication link, the frequency channel FK with the spreading code sk1 is likewise used for transmission. Since the second base station BS2 radiates omnidirectionally in the frequency channel FK in the exemplary embodiment, the information sent by the second base station BS2 in the frequency channel FK impairs the transmission between the first base station BS1 and the first subscriber station MS1, in the form of intercell interference II. The information sent by the subscriber station MSI can also disturb the transmission in the frequency channel of the adjacent radio cell FZ1.

The exemplary embodiment in FIGURE 1 can be regarded as the "worst case", since the same spreading code sk1 on a radio channel FK is normally reused only over great geographical distances, and two adjacent radio cells FZ1 and FZ2, in which the antennas A of the base station BS1 and BS2 radiate omnidirectionally, do not use the same spreading code sk1. Another opportunity for reducing the intercell interference II is to use directionally selective antennas. If the antenna A used in the exemplary embodiment transmits only in the direction of the subscriber station MSI, the intercell interference II is reduced further.

An exemplary frame structure for the radio interface in a TDD transmission method can be seen in FIGURE 2. On the basis of a TDMA component, provision is made for a broadband frequency channel FK, for example having the

bandwidth 5 MHz, to be split into a plurality of time slots ts, for example 15 time slots ts0 to ts14. A transmission channel UK within the frequency channel FK is defined by a time slot ts and a spreading code sk. Within a broadband frequency channel FK, the successive time slots ts are structured on the basis of a frame structure. Thus, 15 time slots ts0 to ts14 are combined into one frame.

When using a TDD transmission method, some of the time slots ts0 to ts7 are used in the uplink, and some of the time slots ts8 to ts14 are used in the downlink, with transmission in the uplink taking place before transmission in the downlink, for example. In between, there is a switching instant SP which is positioned flexibly on the basis of the respective need for transmission channels UK for the uplink and the downlink. The other transmission channels UK are structured in the same way.

Within the time slots ts in a frequency channel FK, information for a plurality of connections is transmitted in radio blocks. These radio blocks comprise sections containing data d, in which sections containing training sequences tseq1 to tseqn known at the reception end are respectively embedded. The data d are spread on a connection-specific basis using a fine structure, a spreading code sk (CDMA code), so that, by way of example, n connections can be separated by this CDMA component at the reception end. The combination of a frequency channel FK, a time slot ts and a spreading code sk defines a transmission channel UK or a signaling channel, which are used for transmitting useful information and signaling information, respectively.

Channel pooling is used to assign one or more transmission channels UK to a communication link in

each case. The channel pooling method is advantageously used to produce communication links to and from subscriber stations MS1, MS2 or MS3 using different data rates or to operate a plurality of services in parallel on one communication link. To this end, a plurality of transmission channels UK are combined for transmission for one connection.

The result of spreading individual symbols of the data d using Q chips is that Q subsections of duration tchip are transmitted within the symbol period tsym. In this context, the Q chips form the individual spreading code sk. In addition, a guard time gp for compensating for different signal delay times on the connections in successive time slots ts is provided within the time slot ts.

The result of separating the information to be transmitted using time slots ts is that the intercell interference II can vary greatly from time slot ts to time slot ts. If the base stations BS1, BS2 are synchronized with one another, so that the time slots ts0 to ts14 for the base stations BS1 and BS2 are transmitted synchronously, the subscriber station MS1 measures the total received power gep (see FIGURE 3) in at least one time slot ts for transmission in the downlink, in order to determine the intercell interference II specific to the time slot.

FIGURE 3 shows, by way of example, a sequence for the inventive method in a TD-CDMA radio communication system. It shows method steps within a subscriber station MS1 and network devices RNC, BS1, and also the signaling and information transmission operations for determining intercell interference II.

In step 1, the network device for allocating radio resources RNC transmits a request to the base station

BS1 to measure the intercell interference II for the subscriber station MS1. The reason for the request is, by way of example, that measurement is necessary in order to update a list for dynamic channel allocation DCA. An alternative reason for the request is that a parameter BER for the reception quality of the information received by the subscriber station MS1 has fallen below a threshold value. The parameter BER is, by way of example, a bit error probability transmitted with signaling information from the subscriber station MS1 to the network device for allocating radio resources RNC.

Alternatively (not shown in the exemplary embodiment in FIGURE 3), the request for measurement is made by the subscriber station MS1. If the parameter BER falls below a threshold value, the subscriber station MS1 measures the total received power gep in at least one time slot ts and signals the measurement results to a network device for allocating radio resources RNC. If the parameter BER falls below a further threshold value, then the network device for allocating radio resources RNC initiates intracell handover for the subscriber station MS1 for one of the previously measured time slots ts. The further threshold value is advantageously stipulated by the network device for allocating radio resources RNC. It is also conceivable for intracell handover to be requested by the subscriber station MS1.

In step 2 of the exemplary embodiment, the base station BS1 transmits a control signal STS in a signaling channel and general signaling information in a pilot channel CCPCH to the subscriber station MS1. The control signal STS is used by the base station BS1 to control measurement of the intercell interference II. The base station BS1 prescribes the time slot ts to be measured, for example, for the

subscriber station MS1.

In step 3, a sum of transmitted powers sks1 to sksn for the spreading codes sk used by the base station BS1 is determined in the time slot ts to be measured. For the pilot channel CCPCH, the base station BS1 ascertains a transmitted power spi. A transmitted power regulator is used to regulate the transmitted power on a transmission channel from the base station BS1 to the subscriber station MS1. From associated regulation parameters, it is possible for a processor (CPU) to determine the transmitted powers sks1 to sksn and to buffer-store them in a memory until the intercell interference II is determined. The transmitted power spi on the pilot channel CCPCH is ascertained in a similar manner, with the transmitted power spi on the pilot channel CCPCH being able to be assumed to be constant over a longer period of time.

In step 4, the total reception line gep for the time slot ts to be measured is measured simultaneously with step 3. The received power epi on the pilot channel CCPCH is also measured simultaneously with the ascertainment of the transmitted power spi on the pilot channel CCPCH. For the measurements, an analog/digital converter is advantageously used which allows the measurement results to be evaluated further using a processor (CPU). The measurement results and evaluation results are stored in a memory in order to produce an average for a plurality of measurements taken at different times or to perform statistical evaluations. The measurement results for the total received power gep and the received power epi on the pilot channel CCPCH are transmitted to the base station BS1 in step 5 in appropriate signaling information.

Steps 2 to 5 are, by way of example, repeated cyclically for at least one time slot ts, and the

results are averaged in order to calculate the variations in the results over a particular period of time, for example 1 second.

In step 6, the base station BS1 determines a path loss pv from the difference between transmitted power spi and received power epi on the pilot channel CCPCH. The intercell interference II for the measured time slot ts is calculated on the basis of the formula

$$II = gep - \sum_{x=1}^{n} (sksx - pv)$$

with all variables in dB. From the total received power gep, the sum of the transmitted powers sks1 to sksn for the spreading codes sk used by the base station BS1 is subtracted in order to obtain the intercell interference II. In one advantageous development of the invention, the intercell interference II together with the spreading codes sk for the time slot ts is evaluated and is temporarily stored, since the intercell interference II varies with the change in the spreading codes sk used in the list for dynamic channel allocation DCA.

To obtain results comparable to the measurements for other subscriber stations MS2, MS3, MSI, the transmitted power sksx for the respective spreading code sk is respectively reduced by the path loss pv. This normalization is also used to compare the base station BS1, BS2 with one another in order to obtain results relating to the interference, the utilization levels and radio traffic density in the individual radio cells FZ1, FZ2.

In step 7, the intercell interference II determined previously is signaled to the network device for allocating radio resources RNC. The network device for

allocating radio resources RNC uses the intercell interference II as an input variable for dynamic channel allocation DCA, for example. Alternatively, (not shown in FIGURE 3), the intercell interference II is calculated in the network device for allocating the radio resources RNC using the formula cited above. To this end, the transmitted powers sks1 to sksn, the path loss pv and the total received power gep are signaled to the network device for allocating radio resources RNC by the base station BS1.

Alternatively (not shown in FIGURE 3), measurement of the intercell interference II is initiated by the subscriber station MS1 by means of access. Random multiple access sent by the subscriber station MS1 in a signaling channel (RACH - Random Access Channel) is received and evaluated by the base station BS1. At the same time as the evaluation, the total received power gep and the received power epi on the pilot channel CCPCH are measured by the subscriber station MS1, and the transmitted powers sks1 to sksn and also spi for one or more time slots ts are determined by the base station BS1. The intercell interference measured is subsequently valid as a decision criterion for channel allocation.